HARVARD COMPUTING CENTER

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A COMPUTER-BASED SYSTEM INTEGRATING INSTRUCTION AND INFORMATION RETRIEVAL: A DESCRIPTION OF SOME METHODOLOGICAL CONSIDERATIONS

by

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Abstract

This report summarizes the initial activities of the Vision Information Center in the field of computer-assisted instruction, from December, 1966 through August, 1967. This work includes the development of a concordance and the conversion of the programmed textbook Basic Ophthalmology (New York: Appleton-Century-Crofts, 1967) by Robert D. Reinecke, M.D. and Robert J. Herm, M.D., to computer-assisted instruction on the IBM 7010 and IBM 1401 systems.*

Essentially this report describes the methodology used to load a large body of text onto a computer. An effort has been made to document and explain all steps, including those which were abandoned, in order to avoid unnecessary duplication in the future.

This project is a joint effort of the Harvard CAI Laboratory and Dr. Robert Reinecke, whose work is supported in part by U.S. Public Health Service Contract No. PH43-66-911.

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*Mrs. Theresa Lee, Dr. Mary Eickhorn, Miss Carol Smith and Miss Dian Ohnsted assisted with different aspects of the work.

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Vision Information Center

The Vision Information Center (VIC) was established to provide computer-assisted instruction (CAI) and bibliographic information retrieval (IR) in the basic areas of interest associated with vision. Its aim is to provide an online computer station which will enable the inquirer to define his questions and then give him direct entrance to and exit from the computer's data bank of bibliographic information. The idea is to combine IR and CAI in one system (see Figure 1).

In order to help relieve the investigator and practitioner of the problem of the rapid proliferation of literature and the difficulty in storing and rapidly retrieving this literature, VIC has undertaken the development of a computer based system to retrieve upon request a bibliography pertinent to the specific interest of the user. In the system design the initial inquiry of the user will be the basis for selective instruction by CAI, both to aid the user in the more precise formulation of his question and to prepare him to better understand the literature he is about to read. The plan is to have the computer select only titles of pertinent literature rather than to present him with an overwhelming and undifferentiated amount of material, much of which is only peripherally related to his subject. Moreover, the computer will accomplish this task in a fraction of the time that is currently required for working with a card catalogue.

The Harvard CAI System not only integrates computer-assisted instruction and information retrieval in a single system but it also

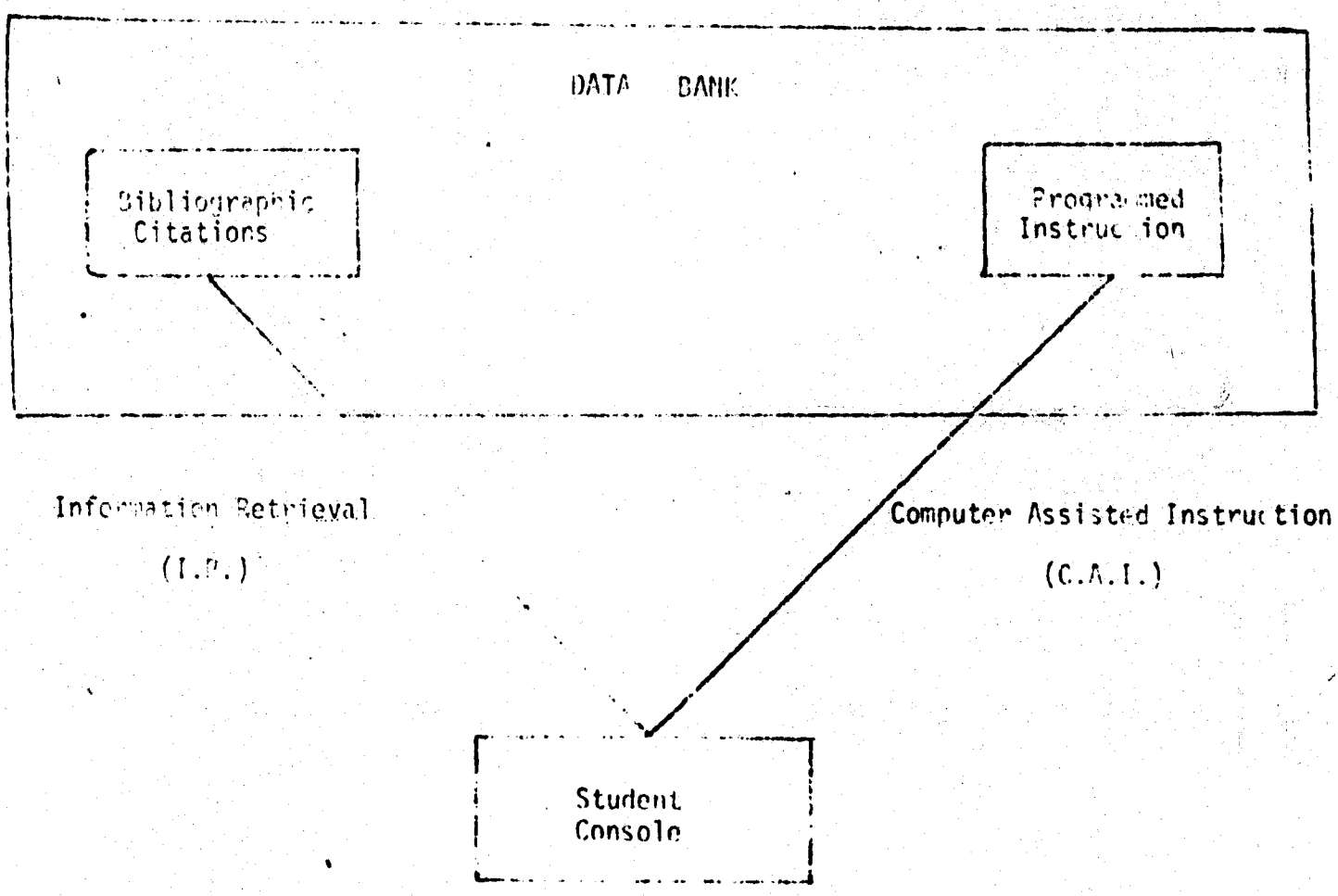

Fig. 1. Vision Information Center -- Harvard CAI Laboratory professional resources system.

makes these services available to the user by teleprocessing. In this way, consoles can be located to suit the convenience of the user.

Operational Characteristics. The two major services of VIC--information retrieval and computer-assisted instruction--are related through key words that are common to both systems. A hierarchical system of key words concerned with vision, called the Thesaurus, has been developed for IR and is presented to the user. Associated with each word is a hierarchical number. When the user types a particular number or set of numbers the computer responds by typing out the bibliographic citations associated with that number and key word. Moreover, the texts of the computer-assisted instruction programs are also indexed by key words, which are listed in the Concordance. The key words of both the Thesaurus and the Concordance receive the same hierarchical number and can therefore be related by the computer.[2]

As presently conceived, the VIC will function as follows: At the computer console, the student will type in his area of interest and will be presented with both the Thesaurus and the option of receiving programmed instruction on the subject. Two alternate routes are open to him. First, if he wishes, he may recieve immediately a list of bibliographic citations only (a set of coded entires in the data base) that deal with the subject of his interest (IR only). If, however, he wishes some instruction on the

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[2]The Thesaurus and the Information Retrieval are being developed by the Countway Library Staff. The Harvard CAI Laboratory Staff assisted in the development of CAI.

subject before he receives the bibliography, he may take the second route and request computer-assisted instruction which will provide specialized branches of information tailored to his individual needs (IR and CAI).

Concordance

Text. The textbook Basic Ophthalmology: A Programmed Text, by Robert D. Reinecke, M.D. and Robert J. Herm, M.D. (1967), is the basis for the computer-assisted instruction developed for the Vision Information Center. Therefore, it is the subject of the Concordance sort for keywords.

The text consists of 656 frames (the details of the programmed instruction format will be discussed in detail in the section on CAI) and approximately 30,000 words.

Keypunch Format. The entire textbook was keypunched on IBM cards to allow for this processing. Columns 1-72 are for text and 73-78 indicate the frame number and the card number per frame. For example, number: 001002 means Frame 1 card 2 (see Figure 2 for details).

Program: Soccer. The program used to develop the keyword concordance was "Soccer"; the programmer was Miss Carol Smith, applications programmer of the Harvard Computing Center. The processing was done on February 15, 1967 and execution took 19.6 minutes.

Approximately 2,700 distinct words types were found. The only words that were placed on the restriction list were an, a, and the. Details of the word occurrences are summarized in Figure 3.

A copy of a portion of one page is included in this report as Figure 4. This is only a portion of the listing for the entry "eye" which is listed 468 times. (Other references which follow

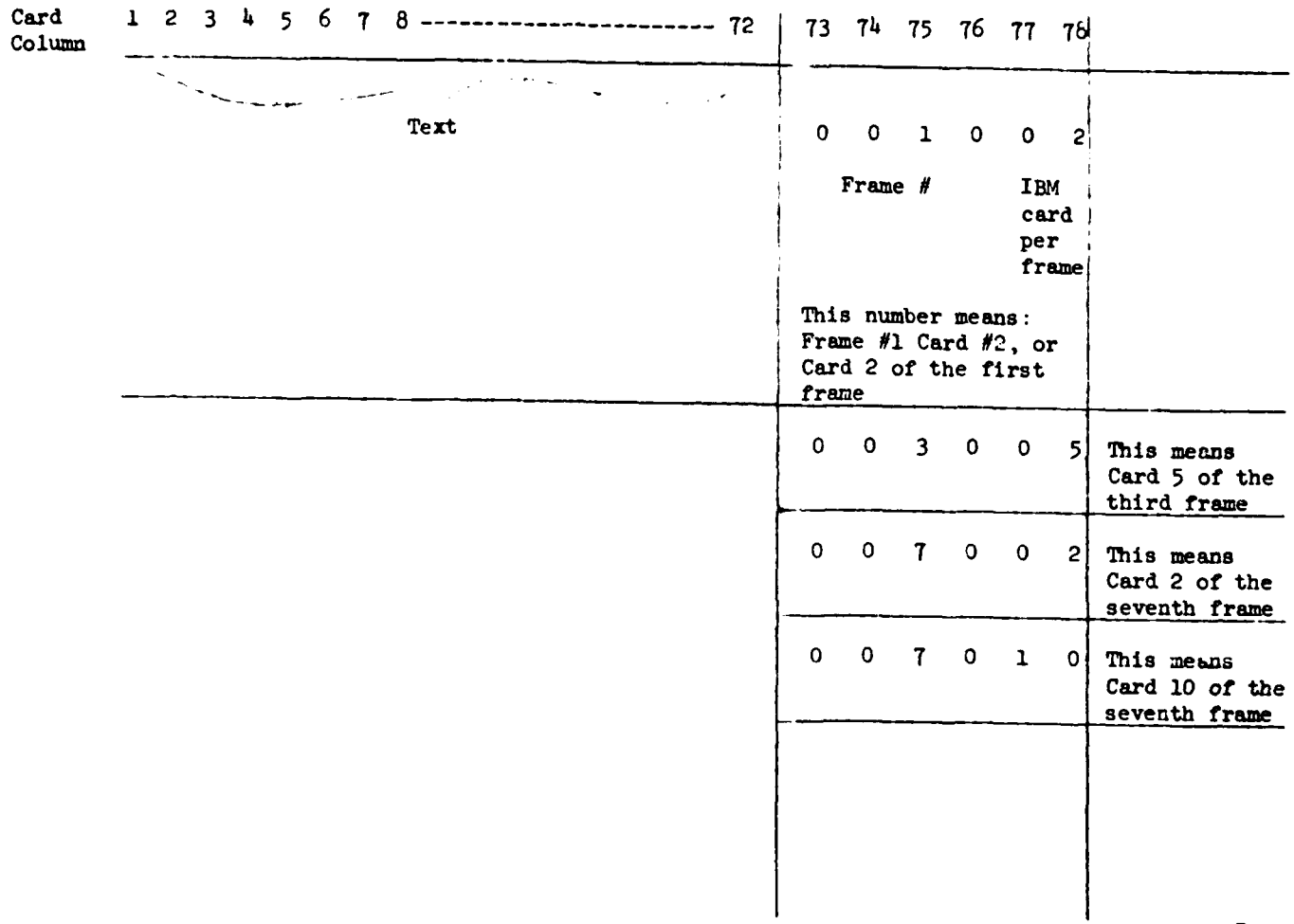

Fig. 2. Concordance--Card Format--Keypunch Instructions.

POST-PROCESSING DATA FROM SOCCER

2/15/67

I. A total of 29,910 words were processed, of which 3,994 were on the restriction list.

II. 2,706 distinct types not on the restriction list were found.

1,016 words occurred once in the text.
423 words occurred 2 times.
252 words occurred 3 times.
160 words occurred 4 times.
120 words occurred 5 times.
95 words occurred 6 times.
74 words occurred 7 times.
50 words occurred 8 times.
45 words occurred 9 times.
32 words occurred 10 times.

III. The most common words not on the restriction list are listed below.

Occurrences	Word
1,296	of
925	is
741	ca
598	and
596	in
585	to
468	eye
308	be
286	or
249	with

IV. The restriction list contains three entries. Occurrences of these entries are below.

Occurrences	Entry
219	an
844	a
2,931	the

V. Execution took 19.6 minutes.

Fig. 3. Results obtained from the analysis of the frames of Basic Ophthalmology.

	EYE		
RIA HAS 1 --- EYES UNLESS ONE	EYE	IS COVERED, WHILE A PATIENT WITH A SQUINT HAS A 2 ---	EY617002
HAS A 2 --- EYE WHEN EITHER	EYE	IS COVERED. CA 1 STRAIGHT	617002
ENT WITH A SQUINT HAS A 2 ---	EYE	WHEN NEITHER EYE IS COVERED. CA 1 STRAIGHT	617003
DISREGARD THE IMAGE FROM ONE	EYE	ALL THE TIME TO AVOID DIPLOPIAA -DOUBLE VISION-. A PATIE	618003
ATIENT WITH A PHORIA USES ---	EYE	-S- AT THE SAME TIME. CA BOTH	618004
COVER ONE EYE AND OBSERVE THE	EYE	BEHIND THE COVER. IF AN EXOPHORIA IS PRESENT THE COVERE	619001
TIENT FOR A PHORIA, COVER ONE	EYE	AND OBSERVE THE EYE BEHIND THE COVER. IF AN EXOPHORIA I	619001
PHORIA IS PRESENT THE COVERED	EYE	WILL DRIFT OUT. AS SOON AS THE COVER IS REMOVED THE DEV	619002
OVER IS REMOVED THE DEVIATING	EYE	WILL MOVE IN, AND THE UNCOVERED EYE WILL -MOVE IN/MOVE O	619003
LL MOVE IN, AND THE UNCOVERED	EYE	WILL -MOVE IN/MOVE OUT/NOT MOVE- -CHOOSE ONE-. CA NOT M	619004
CA HETEROPHORIA IF A PATIENTS	EYE	DRIFTS MEDIALLY AS HE IS OCCLUDED, HE HAS AN 1 ---. IF T	623001
UDED, HE HAS AN 1 ---. IF THE	EYE	OF A PATIENT DRIFTS TEMPORALLY WHEN OCCLUDED, HE HAS AN	623002
AL PHORIAS ARE DENOTED BY THE	EYE	WHICH IS HIGHER IN THE DISSOCIATED STATE. THE EYE WHICH	625001
N THE DISSOCIATED STATE. THE	EYE	WHICH IS HIGHER IS TERMED HYPERPHORIC. IF THE RIGHT EYE	625002
MED HYPERPHORIC. IF THE RIGHT	EYE	IS HIGHER, THE PATIENT HAS A RIGHT HYPERPHORIA. IF THE R	625003
GHT HYPERPHORIA. IF THE RIGHT	EYE	IS LOWER, THE PATIENT HAS A ---. CA LEFT HYPERPHORIA	625004
A PATIENT WHO HAS A DEVIATING	EYE	MUST DISREGARD -SUPPRESS- THE IMAGE FROM THAT EYE, A HAB	634001
SUPPRESS- THE IMAGE FROM THAT	EYE	, A HABIT OF SUPPRESSION MAY BECOME SO FIRMLY ESTABLISHED	634002
A REFERS TO POOR VISION IN AN	EYE	-WITH REFRACTIVE ERROR CORRECTED- WHICH APPEARS TO HAVE	635001
TIENT IS AMBLYOPIC, THE OTHER	EYE	RETAINS OO NORMAL VISION. PATIENT -A,B- -CHOOSE ONE- PR	636001
IA CA NORMAL USUALLY ONLY ONE	EYE	OF A PATIENT IS AMBLYOPIC, THE OTHER EYE RETAINS OO NORM	636001
BEST CORRECTED VISION IN ONE	EYE	IS AT LEAST 2 LINES POORER ON THE SNELLEN CHART THAN THE	637002
SNELLEN CHART THAN THE OTHER	EYE	AND NO ORGANIC PATHOLOGY IS SEEN. FROM THE FOLLOWING REC	637003
RECORDED VISUAL ACUITY, WHICH	EYE	HAS THE AMBLYOPIA -IF NO ORGANIC DISEASE IS PRESENT-.	637004
RING A CONDITION IN WHICH ONE	EYE	WAS MYOPIC AND THE OTHER EYE HYPEROPIC.	638002
EYE WAS MYOPIC AND THE OTHER	EYE	HYPEROPIC. CA ANISOMETROPIA	638003
PIA. IN SQUINT, THE DEVIATING	EYE	MAY SUPPRESS VISION TO AVOID DIPLOPIA. IN ANISOMETROPIA,	641003
PLOPIA. IN ANISOMETROPIA, THE	EYE	WITH THE GREATER REFRACTIVE ERROR MAY SUPPRESS VISION TO	641004
-- IS COMMON IN THE DEVIATING	EYE	IN SQUINT AND IN THE MORE AMETROPIC EYE IN ANISOMETROPIA	641005
INT AND IN THE MORE AMETROPIC	EYE	IN ANISOMETROPIA. CA SUPPRESSION	641006
E STRABISMIC PATIENTS USE ONE	EYE	PART OF THE TIME, THEN SWITCH TO THE OTHER EYE. THIS SW	643001
IME, THEN SWITCH TO THE OTHER	EYE	. THIS SWITCHING BACK AND FORTH ALL DAY LONG ALLOWS EACH	643002
RTH ALL DAY LONG ALLOWS EACH	EYE	TO BE USED. WOULD AMBLYOPIA BE EXPECTED IN AN ALTERNATIN	643003
ENT SQUINT DOES THE DEVIATING	EYE	SUPPRESS VISION AT ALL TIMES. CA NO	644003
POOR VISION OF THE AMBLYOPIC	EYE	IS DIFFERENT FROM THE POOR VISION OF A DISEASED EYE. TH	646001
THE POOR VISION OF A DISEASED	EYE	. THE AMBLYOPIC EYES VISION DOES NOT DECREASE ABNORMALLY	646002
INATION, WHEREAS THE DISEASED	EYE	HAS DISPROPORTIONATELY DECREASED VISION IN LOW ILLUMINAT	646003
HAS A VISION OF 20/200 IN AN	EYE	WITH RETINAL DISEASE, AND A VISION OF 20/200 IN THE OTH	646005
EYE, THAT IS AMBLYOPIC, WHICH	EYE	WOULD FUNCTION BETTER AT NIGHT.	646006
ISION OF 20/200 IN THE OTHER	EYE	, THAT IS AMBLYOPIC, WHICH EYE WOULD FUNCTION BETTER AT N	646006
ER AT NIGHT. CA THE AMBLYOPIC	EYE	OFTEN THE AMBLYOPIC EYE WILL NOT BE ABLE TO READ A LINE	646008
/OPIC EYE OFTEN THE AMBLYOPIC	EYE	WILL NOT BE ABLE TO READ A LINE OF LETTERS, BUT WILL BE	647001
/ISUAL ACUITY IN AN AMBLYOPIC	EYE	TO BE BETTER IF SINGLE LETTERS OR LINES OF LETTERS ARE U	647003
SINGLE LETTERS THE AMBLYOPIC	EYE	WILL OFTEN NOT BE ABLE TO READ A LINE OF LETTERS, BUT WI	648001
/ISUAL ACUITY IN AN AMBLYOPIC	EYE	TO BE BETTER IF SINGLE LETTERS OR LINES OF LETTERS ARE U	648003

Fig. 4. Concordance.

alphabetically: concord eyeball, eyeballs, eyed, eyelashes, eyelid, eyes). Every time the word appears it is listed in the center of the program within the context of the words that immediately precede and follow it in the textbook. In the right hand column, the numbers identify the frame number and also the IBM card in which a particular occurrence of the word is located (see Figure 2, the keypunch instructions). For example, on page 269 of the program (Figure 4) the first mention of the word "eye" is on frame 617, card #2.

The words are listed by alphabetical groups with each group in ascending numerical order by frame number.

Pilot Concordance. A pilot Concordance was run on Frames 1-49 first on January 19, 1967, to test the program for accuracy and appropriateness.

The Task. The task was to load the programmed linear text Basic Ophthalmology: A Programmed Text, of approximately 30,000 words, onto the computer, complete with commands to show slides. Its conversion to the form of CAI was divided into two stages:

Stage I included (a) loading the linear programmed text on the CAI system, in essentially the same form as it appeared in the textbook, and (b) collecting student responses to the frames. The liear text was tested by medical students through the use of both the on-line CAI system and the published text of the book in its test edition.

Stage II included (a) editing and changing the loaded program based on an analysis of student answers. The process of data

analysis will be discussed in the section on the IBM 1401, but essentially it involves determining the students' wrong answers, writing branches and then editing the existing linear frames to provide supplementary remedial instruction in these areas of difficulty. (b) A second group of students will test the edited program with branches. Other modifications will be made and, if no further major changes are necessary the program will be available for use. The on-line editing capability of the computer allows other branches to be added from time to time to keep the program up-to-date with growing student use and to constantly expand its branching possibilities.

Coursewriter. The programming language used was Coursewriter, which was compatible with the IBM 7010 computer in The Thomas J. Watson Research Laboratory at Yorktown, New York. The complete details are given in the 7010 Coursewriter manual available from the IBM Yorktown laboratory.[3]

The Test Course: basophth. The first stage of loading Basic Ophthalmology onto the CAI system was to load a small test deck called basophth in order to test the correctness of the programming format and the loading and editing procedures. Simultaneously, we experimented with other test courses to enable us to make editing changes without interfering with the content of basophth. The printouts of these courses have been bound separately and are labelled anal08, testrun, and tesophth2.

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[3]Mr. Thomas Hartman coordinated this work.

Frames 1-6 were entered by keypunch and frame 11 was entered on-line during the week of April 1, 1967. They were accessible as teaching units to the students, complete with commands to display slides.

Coding. Frames 1-6 were taken from the text and hand coded on IBM coding sheets by Barbara Ricker and Judith Selig. A detailed explanation of the coding format is given in the section on basicoph.

Keypunching. Keypunching was done most effectively at the Harvard Computing Center, where the deadline is guaranteed, the 80.80 listing is provided and accuracy is very high. The material was proofread in Cambridge and keypunch errors were corrected before the deck was mailed to Yorktown, so that any changes which were necessary after the material had been entered would probably be changes of format and not clerical spelling errors.

Card Duplication. Next, the cards were duplicated at the Harvard Computing Center and the duplicate deck mailed to Yorktown for card loading.

We thought it advisable to keep the original deck, or a copy, at the Computing Center in case the mailed copy should be lost or damaged. Also, in case any duplications were incorrect in the mailed-out version, we would still have the original good version in our possession and would not have to rely on the Yorktown lab to send us a copy of its deck (a process which is time-consuming and inconvenient and might, indeed, be overlooked).

The duplication of these decks demands extreme care since some of the multiple punches (e.g. 11, 5, 9) are used only in the

Coursewriter system, and hence are regarded as illegal characters. Experience showed that the original deck should be duplicated on the 1401 since that computer will process and duplicate the "illegal" keypunches. Each duplicated deck should then be compared card to card with the original (in a spot check) to be certain the duplication is accurate. A card listing is also helpful.

Card Loading. Next, the cards were mailed to Yorktown for card loading.

Compile Listing. The Yorktown lab immediately sent us a compiled listing of the entire course entered to date.

Editing. The course, in the student mode, was taken by Miss Selig several times at the 1050 console located in the Massachusetts Eye and Ear Infirmary, 28 Emerson Place, Boston in order to test the program. In the course of this testing, an editing form was developed to enable the author to go through each frame several times, testing several different aspects of the program (see Figure 5 for an example).

In addition, a second editing form was developed to facilitate on-line changes. Theoretically, if the form is filled out with complete information, a typist who knows nothing about the course *per se* but knows some Coursewriter and how to operate a 1050 console can enter the material on-line (see Figure 6).

Results. In addition to affirming the validity of the programming we made two important observations based on the test course basophth:

Frame Number ML

Edit Form - 7010

Trial	FP (Slide Command)	CA	CB	FN ED	FN KW KWO	FN KWO	NX TY	Comments
1								
2								
3								
4								
5								
6								
7								

Fig. 5. Example of Edit Form for the IBM 7010.

Edit Form - 7010

Additions and Corrections to Text

Sequence No.	TAB	LABEL	TAB	Op Code	Space or C/R	Text

Fig. 6. Supplementary form for editing.

1. Hand coding for keypunch is definitely not practical and reproducing card decks would be very helpful.
2. The two editing forms are helpful.

Basicoph--Card Loading. While the logic of the Coursewriter language is relatively simple and eacy to apply, the actual process of entering the material into the computer requires great exactness of detail.

In cosidering how to enter Basic Ophthalmology in Coursewriter form, we chose card loading instead of on-line entry for the following reasons:

1. The course already existed on previously punched IBM cards (for the Concordance)
2. Its pattern of programming would be uniform
3. It was a substantial body of material (30,000 words)

See Figure 7 for details.

Keypunch Coding. A Master Coding Sheet giving the details for program flow and keypunch specifications for one frame was written. This was the standard form for all frames. It was quickly evident how much of the coding was repetitious and could be reproduced (see Figure 8).

The coding underlines in red (thin lines) is identical in every frame. The coding underlined in green (thick lines) can be mechanically sequenced.

Moreover, some of the coding is extremely exacting, requiring two or three numbers in one IBM card column (multiple punches). See Figure 8; Figure 9 for further details.

1. Basic Ophthalmology: A Programmed Text--linear form, on keypunched card deck, called Input deck.

2. Rewrite one frame on basic Coursewriter form--program flow only.

3. Write Master Coding Sheet--the Coursewriter format for keypunching--with exact specifications as to column position and multiple punch combinations.

4. Analyze Master Coding Sheet to determine which of the op codes and statements can be reproduced and which can be taken from the original Input deck.

5. Reproduce uniform cards — Transcribe Input deck on new cards in Coursewriter format called Conversion deck.

6. Manually collate the two decks according to Master Coding Sheet pattern.

Fig. 7. Steps in the Card Loading Procedure.

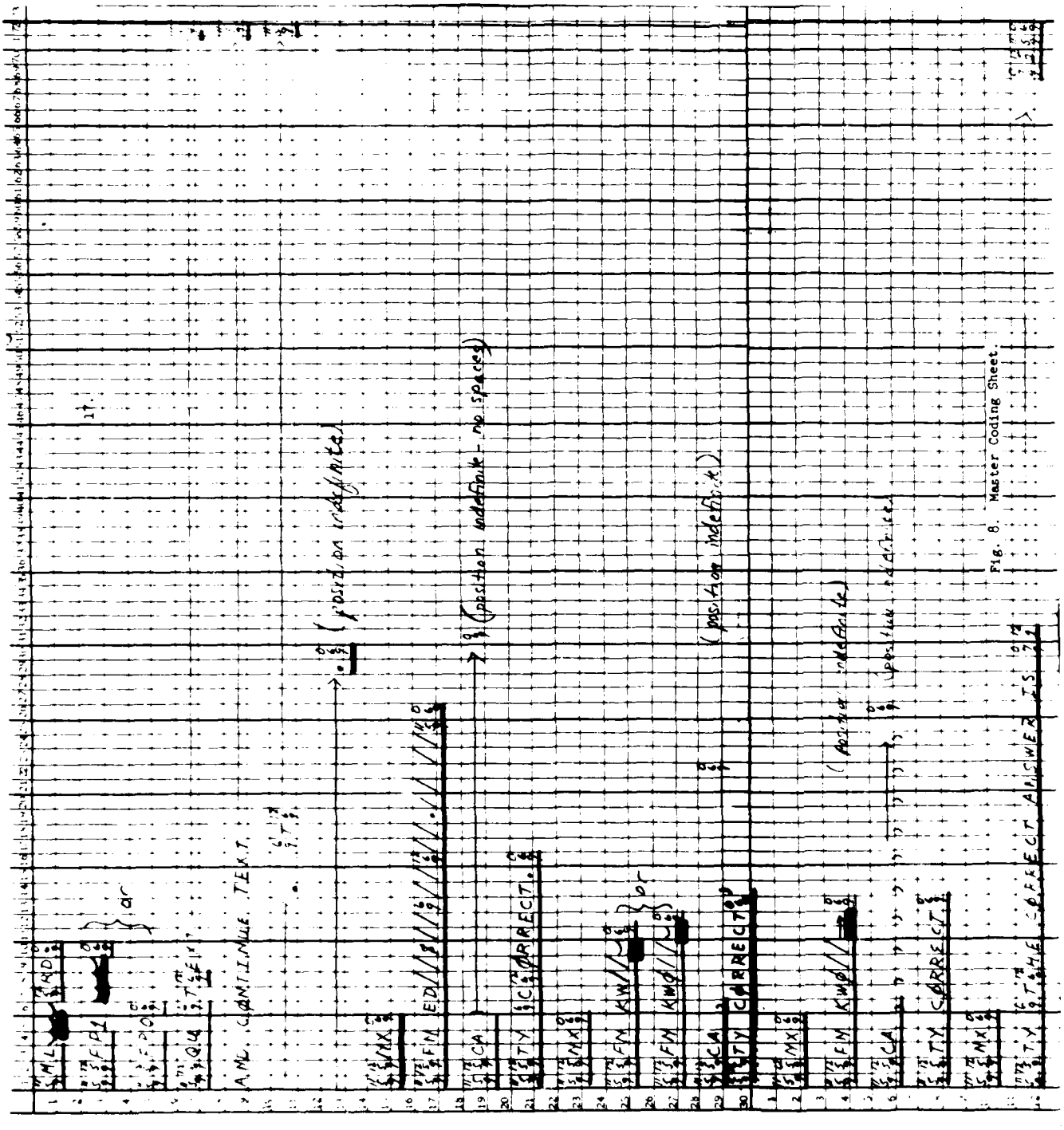


Fig. 8. Master Coding Sheet.

Courserwriter Symbol	Keypunch Coding	Print-out Symbol
] Carriage return	11 5 9	*
[tab	12 5 9	)
upshift	6 9	=
downshift	12 6 9	.
EOB	0 6 9	,
pre A red shift Prefix A	0 12 7 1 9	(A
pre B black shift Prefix B	0 12 7 2 9	(B

Fig. 9. Symbols for special characters used in keypunching for the IBM 7010.

Reproducing. The advantages of reproducing cards that are repeated consistently and in great quantity throughout the program cannot be overestimated (see Figure 10).

An examination of the master programming sheet reveals that 80% of the programming op codes are uniform or of largely repeated patterns throughout the entire program of Basic Ophthalmology. The actual number of cards this represents is 50% of the total number of 5,000 cards entered. To hand code these cards for keypunching would be a formidable task indeed. The coder would have to keep in mind not only the general flow of the program and order of op codes, but also the exact form, the detail of multiple punches, EOBs, etc. Moreover, the possibilities of error are enormous when one considers the fallibility of the hand coder and the keypuncher. The time required for proofreading these cards would also be enormous because the coding must be exact in respect to column position, multiple punch combination, etc. or the op code will not be executed.

Therefore, it seemed much wiser to reproduce the repeated cards and manually combine them with the converted deck. In contrast to the individual coding method, the reproduced cards need to be hand coded only once, keypunched only once and proofread only once. They may then be duplicated literally by the thousands, the collater merely collating stacks of cards in a given order, much as one collates the pages of a manuscript. The entire process, a highly technical one, can be reduced to a relatively simple clerical task, at a great saving of time and expense.

	% of op codes	% of cards
Reproduction	80%	50%
Conversion Deck	20%	50%

Fig. 10. Reproduction and Conversion Deck Ratio.

7010 Mass Production Coding Forms. When hand-coding was necessary and there was still a great repetition of detail, the coding sheet was filled out with the repetitious parts and reproduced by Xerox. Then the additional information, which changes in every slide, was filled in where appropriate (see Figure 11). Arrows indicate the places where additions are needed.

The details of writing a conversion program are discussed in the section on the IBM 1401 since that is the program currently in use.

Collating. See Figure 12 for the steps in the collating process.

Moreover, color coding can facilitate the process. We reproduced different op codes on cards of different colors:

ML (label) -	blue
FPO and FP1 - (slide commands)	beige with top orange stripe
NX -	pink
FN ED KW - KWO	yellow
TY -	orange
QU and CA - (conversion deck)	beige with top yellow stripe

Card Loading. After the course was collated it was duplicated and divided into 13 separate and smaller courses. They ranged in name from basicoph1 through basicoph13. Shorter courses facilitate

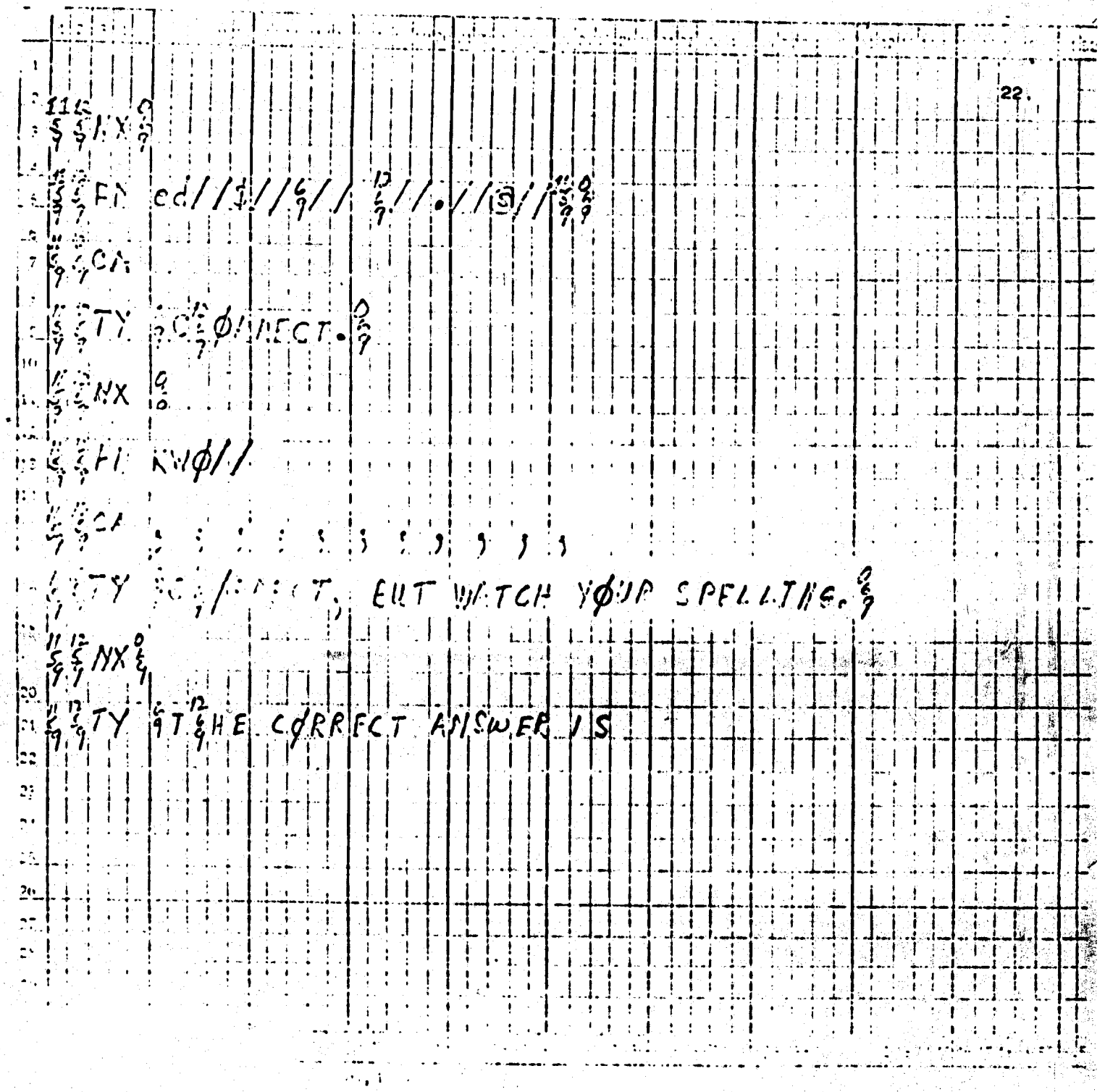


Fig. 11. Mass production for 1 CA-Coding Sheet (partial).

1. Collate reproduced material

   a.

      NX

      fn ed

      ty Correct.

      NX

      ty correct

      NX

   b.

      ml and FPi.

      ml and FPO

   c.

      combine groups a and b

2. Insert Conversion deck in the collated reproduced deck
3. Insert KW// and KWO// cards in combined decks
4. Add lead Cards

Fig. 12. Steps in collating.

compiling after editing on the IBM 7010 (see Figure 13 for the index of course names--the frame numbers included in each course and the course sequence numbers). The courses are connected by an automatic connect function which enables the student to go from course to course without interruption. Hence, it is necessary to have continuous sequence numbers.

A duplicate copy of the deck was mailed to Yorktown and compile listings of basicoph1-3 were returned.

On-line Basicoph. To sign on the system for basicoph at Yorktown one needs to know the following information:

Yorktown--7010

Sign-On Information

basicoph	=	(course name)
b1079	=	(author/student number)
hvic.	=	(author/student name)
hcai	=	(school)

The exact process for sign-on in both the author and student modes is given below.

Sign-On--basicophl

AUTHOR Mode

Computer	:	(Proceed light goes on)
Author	:	(Press EOB)
Computer	:	Make a request
Author	:	Coursewriter, basicophl, b1079

Sign-On--basicophl

STUDENT Mode

Computer	:	(Proceed light goes on)
Student	:	(Press EOB)
Computer	:	Make a request
Student	:	b1079, basicophl, hvic

The computer will automatically begin where the student stopped the previous time. To go to the beginning of the course, press the carriage return button, type AB-0010-020, press EOB (2 red buttons).

Multiple Program Patterns. In the early stages of programming basicoph for the IBM 7010 we thought of having several different types of programs for several different types of frames.

	Frame No.	Sequence No.
basicoph1	0-49	AC-
basicoph2	50-99	BC
	100-101	BD
basicoph3	102-122	CC-
basicoph4	123-196	DC-
basicoph5	197-239	EC
basicoph6	240-293	FC
basicoph7	294-335	GC
basicoph8	336-399	HC
basicoph9	400-449	IC
basicoph10	450-503	JC
basicoph11	504-549	KC
basicoph12	550-599	LC
basicoph13	600-656	MC

Fig. 13. Course index for basicoph.

We found that the 656 frames of the programmed text Basic Ophthalmology can be divided into several distinct and often repeated patterns of CAI programming. Distinctions were drawn between the frames on the basis of the number of CA's, whether the CA's were ordered or not, and whether there were any CB's or synonyms or any alternate forms of CA's. Each pattern of program format was given a distinct number, and this number was marked next to hhe frame in the margin of the programmed textbook (copy 111) for easy referral (see Figure 14 for definitions of types).

Then we began the calculating of a frequency distribution of the number of occurrences of each pattern.

The plan was to develop mass production coding methods for all the different types of CA's. Ideally, this procedure would have provided a more detailed and individualized conversion to CAI than one uniform format. However, we had only a few weeks to load the course onto the IBM 7010 system. In addition, the amount of anticipatory coding for misspelled words in mutiple CAI frames was enormous, and we were not at all sure that the variations would be used by the students. Therefore, we decided to wait for empirical data on what wrong answers the students actually gave and proceeded to enter the course in its linear form.

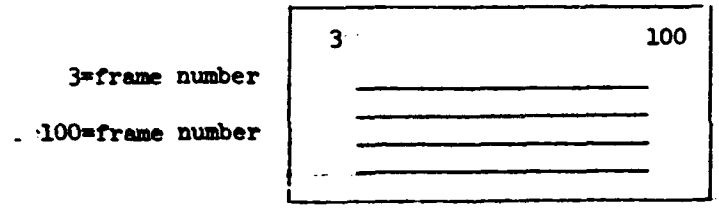
Wrong-Answer Processing. The Basic Ophthalmology course in textbook form has been, and will be, given to medical students, interns, residents, and related personnel. We plan to record their wrong answers and then write branches for the CAI version of Basic Ophthalmology to expand on these areas of difficulty.

	Number of CA's
1	1
1+	
	Ordered
2	2
2+	
3	3
3+	
4	4
4+	
5	5
5+	
6	6
6+	
	Any Order
12	2
12+	
13	3
13+	
14	4
14+	
15	5
15+	
16	6
16+	
0	no coding
20	no CA's (rd - ty statement)
21	students sketch their response
22	omit the frame from the CAI
+	CB

Fig. 14. Program pattern types.

Student's Task. Students are allowed to keep their copy of the textbook if they copy their wrong answers on individual 3 x 5 cards in the following manner:

1. The frame number appears in the upper left hand corner.
2. The student I.D. number which corresponds to the previously assigned number of the book appears in the upper right hand corner.
3. The text is written on the face of the card, and continued on the back of the same card if necessary.



Keypunch Format. Next the wrong answers are keypunched on 80 column IBM cards to provide for computer data processing (see Figure 15).

Column Number.

1	= Basic Ophthalmology text, is always 2 for this processing
2, 3	= Institution identification number (see Figure 16)
4	= Month of the year (see Figure 17)
5, 6	= Year
7	= Blank

8, 9, 10	= Frame number (3 digits, all columns punched, use leading zeros if necessary)
11	= Blank
12, 13, 14, 15	= Student Identification Number
16, 17	= Blank
18-72	= Incorrect Answer

If text of comments continues to a second card, duplicate columns 1-17 and continue text in column 18. (In key-punching, substitute)7 for △ , since there is no △ on the keypunch.)

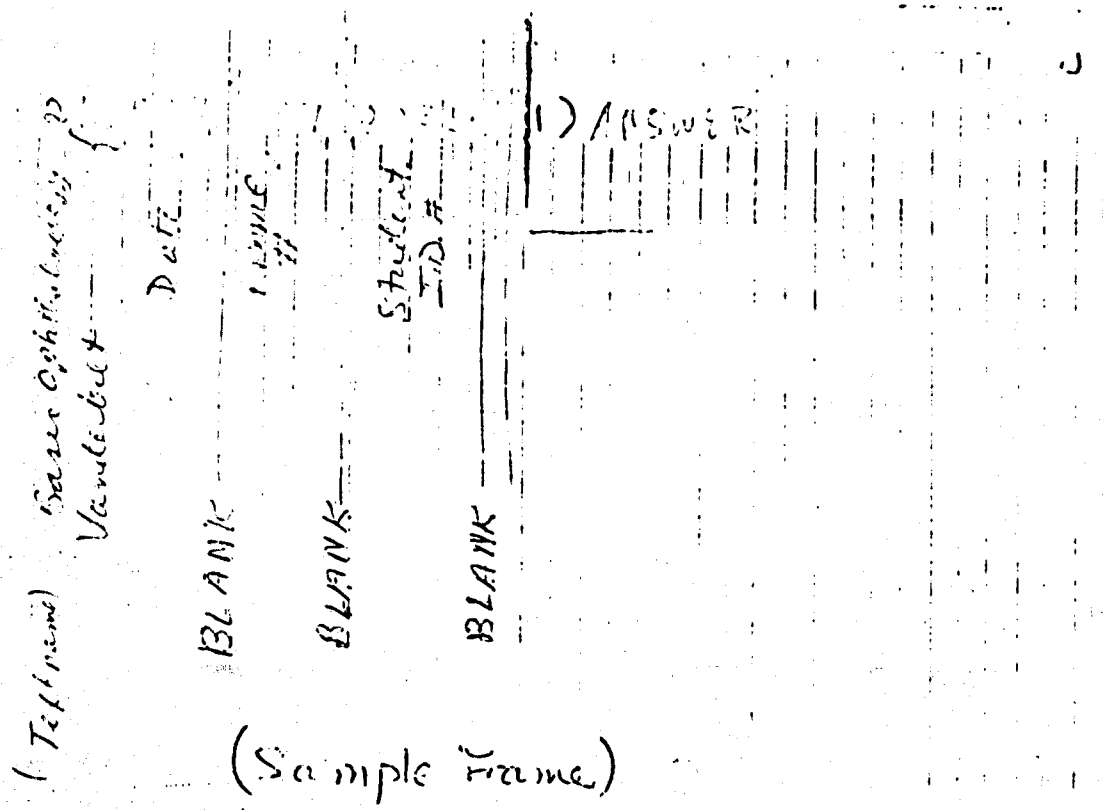


Fig. 15. Keypunch format for processing students' wrong answers.

Code Number	Institution Name
11	Vanderbilt Medical School
12	West Virginia Medical School
13	Laboratory Assistants, not M.D. or Student M.D.
14	Harvard Medical School
15	
16	
17	
18	
19	

Fig. 16. Keypunch coding of names of institutions for Basic Ophthalmology course.

Code Number		Month
1	=	Jan.
2	=	Feb.
3	=	March
4	=	April
5	=	May
6	=	June
7	=	July
8	=	Aug.
9	=	Sept.
0	=	Oct.
-(11 punch)	=	Nov.
+(12 punch)	=	Dec.

Fig. 17. Keypunch coding of names of months for Basic Ophthalmology course.

IBM 1401--Providence

CAI Loading. On August 8, 1967, the Basic Ophthalmology textbook was loaded on the IBM 1401 CAI system at Providence College (see Figure 18 for details of the system). It was loaded in the linear form, parallel to the format of the textbook, in the Texas version of the Coursewriter language used at Providence College. The next step is to write branches to the text and add them to the existing system.

Medical students read the text in book form and their errors are recorded. Branches for the CAI system will be written on the basis of these errors. The principle behind writing branches for the Basic Ophthalmology text is not to predict student errors, except in specific limited instances, but to incorporate those that are known to occur.

Conversion Program. Since the text of Basic Ophthalmology was already on keypunch cards (it was punched to produce the Concordance) and because on-line time is scarce and expensive, we decided to card-load the material.[4] Judith Selig provided the basic pattern of program flow from the 7010 Master Coding Sheet and Mrs. Theresa Lee translated it into the 1401 version of Coursewriter keypunch coding; from this, Mr. Bromley wrote the conversion program.

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[4]Mr. Al Bromley, Systems Programmer, wrote the Conversion Program from the original input Concordance deck to the IBM 1401 format.

As in the 7010 program, the majority of the coding is repetitious and can be reproduced. However, instead of reproducing and manually collating the cards, we arranged to have the 1401 program generate and place the repetitious cards. The only ones that had to be manually collated were the commands to display and remove slides, since they were not present in the original input deck. These cards were generated separately and then inserted. The complete deck was duplicated and the original copy taken to Providence College for card loading.

Conversion Flags. In order to produce a Coursewriter deck from a plain input deck, two major flags are needed. One must show the beginning of the question text and the other the beginning of the answer text, in order to delimit the two. QU for question and CA for answer served our purpose, since they are consistent with the Coursewriter programming, but any symbol would be sufficient. If the slide numbers are present in the input deck, then the Coursewriter slide commands can also be generated and sequenced.

In addition, it is a good rule to keypunch sentences in the conversion deck by ending them with a period and spacing twice before beginning a new sentence. Then the computer conversion program can be programmed to capitalize the third character after a period:

$$\underset{1\ 2\ 3}{.\ \_\ \_\ \text{T H E}}$$

In this way capitalization in the input deck can be provided with a minimum of error.

Editing the 1401 Program. After the conversion program was completed, a 1401 CAI version of Basic Ophthalmology was produced.

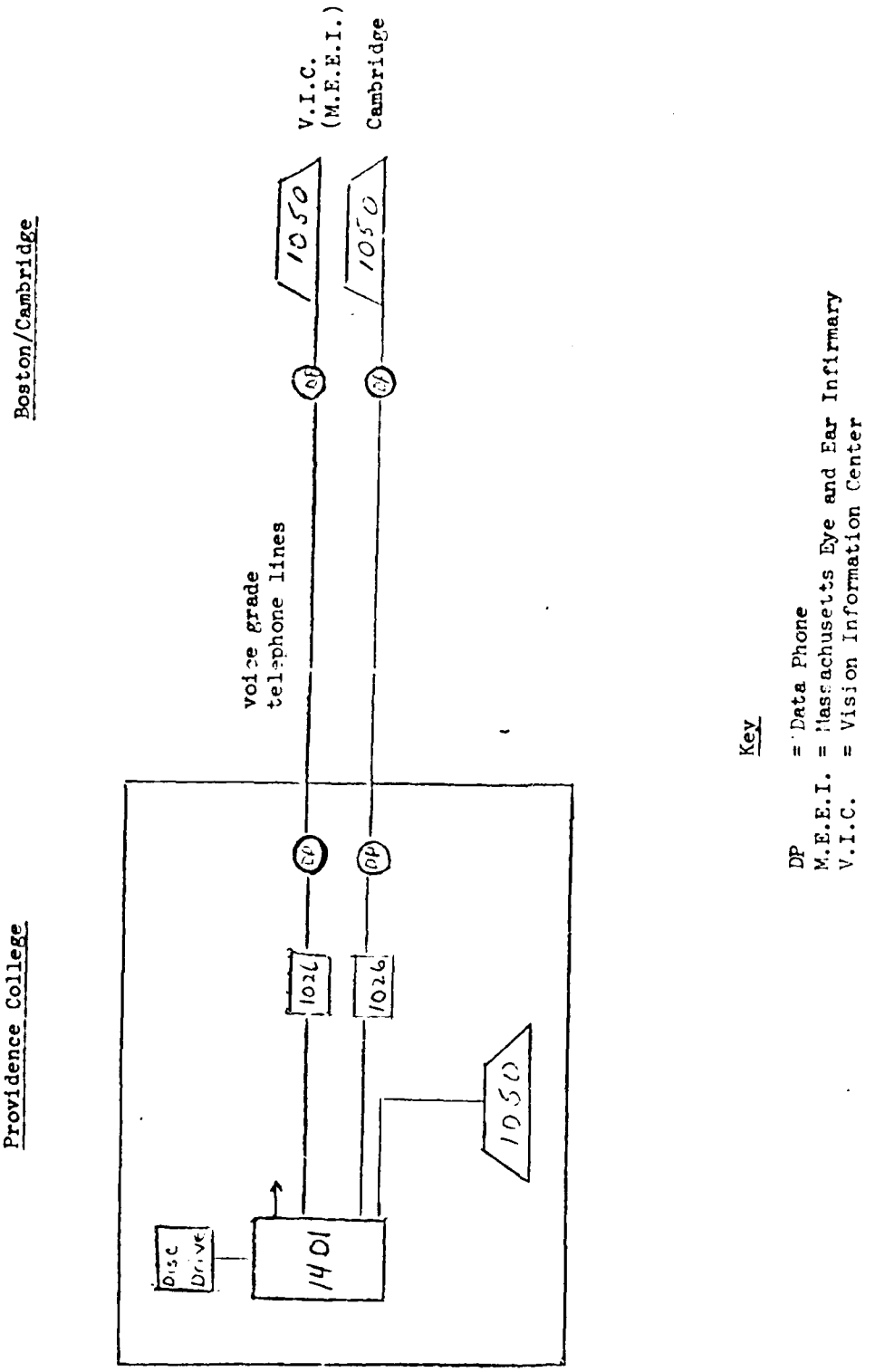

Fig. 18. CAI Equipment, IBM 1401 System, Providence, R.I.

We found that a great deal of editing was necessary to make the program ready for students, so we utilized the on-line time for this job. Of course, the printout was hand-edited prior to on-line text editing. Approximately 80 hours of on-line time were required to edit the program.

Student Participation. Several ophthalmic assistants were asked to take the Basic Ophthalmology course at the console. They found the experience stimulating; their interest was maintained for as long as two hours of continuous on-line time. Unrecognized answers or wrong answers were keypunched on cards and identified by appropriate frame numbers. These cards were then sorted according to the frame numbers and used to produce a printout to evaluate student responses.

Summary

This report briefly describes the Harvard University professional support system combining computer-assisted instruction and information retrieval. It also details the procedures used in converting a linear self-instructional program to computer form so it could be run under Coursewriter, first on an IBM 7010 and then on an IBM 1401. Procedures, forms, and findings are described. Further use is planned for the program which now has been converted to a third system.

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13. ABSTRACT

This report summarizes the initial activities of the Vision Information Center in the field of computer-assisted instruction, from December, 1966 through August, 1967. This work includes the development of a concordance and the conversion of the programmed textbook Basic Ophthalmology (New York: Appleton-Century-Crofts, 1967), by Robert D. Reinecke, M.D. and Robert J. Herm, M.D., to computer-assisted instruction on the IBM 7010 and IBM 1401 systems.

Essentially this report describes the methodology used to load a large body of text onto a computer. An effort has been made to document and explain all steps, including those which were abandoned, in order to avoid unnecessary duplication in the future.

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